N° XXIII.

A Thermometrical Journal of the temperature of the atmoſphere and Sea, on a voyage to and from Oporto, with explanatory obſervations thereon.

Philadelphia, Sept. 18, 1792.

SIR,

Read Sept. 21ſt, 1792. ON the 15th of June laſt Capt. William Billings of this city, commander of the ſhip Apollo, preſented the journals of his voyages to and from Oporto, for the inſpection of the American Philoſophical Society. As they were not accompanied by any explanatory memoir, I have extracted from them what alone differs from ſea reckoning in general, and incloſe a thermometrical journal of the temperature of the atmoſphere and ſea, which evidently appears to be the object of the communication. As it was proper to ſhow that theſe obſervations were not imaginary, and had ariſen in the courſe of his voyages, Capt Billings preſented his whole journals, conſiſting of 73 pages in folio, with all the detail of a log book, which in original are depoſited among the ſociety's papers. *

As the experiments of this intelligent navigator, appear to be repetitions of thoſe I made near two years before, which are related in my memoir No. X. page 82 of this volume, I beg leave to make the following obſervations on them.

By theſe journals it appears that in June, 1791, the water on the coaſt was at the temperature of 61°. by Fahrenheit, and in the Gulph ſtream at 77°. By my journals it will be found that in November, 1789, the water on the coaſt

* The temperature of the water was tried ſeveral times every day, but in this extract it was thought proper only to notice the important changes, a ſucceſſion of ſimilar reſults being thought unneceſſary.

coaſt was at 47°. and in the gulph ſtream at, 70°. viz.

By Capt. Billings,		By my experiments		diff. between June and Nov.
1791, June, coaſt,	61	1789 Nov. coaſt,	47	14°.
do. Stream,	77	do. ſtream,	70	7
do. ſtream warmer,	16	do. ſtream warmer	23	

Hence it may be concluded that although this difference of heat is more remarkable in winter than in ſummer, yet it is ſufficient at all times to guide navigators, ſo as to take the benefit of its current in going from, and to avoid its oppoſition in coming to America.—In the latter caſe, it has this additional convenience in correcting a reckoning; for if a navigator can, by this means, know the moment he is within the ſtream, he knows at the ſame moment his relative ſituation as to the coaſt; and if by repeated experiment this mode of correction ſhould be found ſolid, it amounts, in effect, to a certainty of the longitude, at the preciſe time when it is important to be accurate.

Captain Billings' courſe being nearly along the ſtream, he found only ſuch alteration in the heat of the water as may be accounted for by the cooling of the ſtream itſelf, in its courſe to the northward, 'till he came to lat. 39. 00. N. long. 56. 00. W. (a breaſt of the Banks of Newfoundland) when the mercury fell 10°. Doctor Franklin, in November, 1776, on board of the Repriſal, in lat. 41. N. long. 46. W. found about the ſame difference; but the Repriſal had kept a courſe farther ſouth and came into this cool water in a N. N. E. direction; while Captain Billings being farther North, came in an eaſterly direction, and of courſe might be as much within the influence

of that chain of banks which extends from the longitude 45 W. along the American coaſt, as the Repriſal was when ſo much farther to the eaſtward. In November 1789, I found the ſame difference in lat. 40. N. long. 49. W. after ſailing in a direction about N. E. and a line being drawn from the place where Captain Billings's change happened, to that where Doctor Franklin's thermometer fell (in a direction about E. N E.) would nearly interſect the place where I obſerved the ſame alteration; this is about the ſweep of the banks, known by frequent ſounding, as will be found by conſulting the beſt charts.—By the coincidence of theſe three journals, at ſo great a diſtance of time, and without any knowledge of, conſequently without any connection with each other, this important fact ſeems to be eſtabliſhed. *A navigator may diſcover his approach towards objects of danger, when he is at ſuch a diſtance as to be able eaſily to avoid them, by attentively examining the temperature of the ſea.*

After having paſſed the banks, Captain Billings found but little difference during 18 days ſail, till he came near the European coaſt. The ſame uniformity appears in my journal on a voyage to England, Page 85 of this volume.

Captain Billings found the water to grow cooler three days before he made the land, and the mercury fell gradually from 65 to 60° when the land appeared: this was in June. In November I found on approaching the Engliſh coaſt a gradual fall from 53 to 48° and then we ſtruck ſoundings. Here the difference between the ſea and coaſt water was in both caſes the ſame, though the heat of both varied with the ſeaſon.

Returning from Oporto, Captain Billings marked his approach to, and departure from the weſtern Iſlands by the changes of his thermometer, but in this caſe the difference was ſmall; becauſe, owing to the climate and ſize

of

of theſe Iſlands, the land cannot be ſo cold as a northern continent naturally muſt be. Indeed, the uſefulneſs of the thermometer ſeems to be applicable to the more dangerous ſituations, and not to Iſlands in warm climates; I ſhould ſuppoſe, for obvious reaſons, that the changes would not be great about the Iſlands ſituated between the tropics. The ſhore of theſe Iſlands is generally bold, and the land being very high, may be ſeen at a great diſtance. The climate is not ſubject to fogs, ſnow ſtorms, Iſlands of Ice, long nights, &c. ſo that, except hurricanes, (which are more fatal to ſhips in port than at ſea) there ſeems to be but little danger in ſuch navigation.

After leaving the weſtern Iſlands, Captain Billings ſteered to the weſtward, being in nearly the ſame lattitude on the 30th (37° 47° N.) that he was on the 17th of Auguſt. (37° 53° N.) but during the intermediate time he was driven, as winds prevailed, in a zig zag courſe, as far North as 39° 04 N. and as far ſouth as 36° 26 N. It appears alſo during this time that his thermometer varied from 1° to 5°; but it is to be remarked that there is a medium in his thermometrical variations anſwering to the medium of his lattitude. When he was in 39° 04. the thermometer marked 75° and when in 36° 26. it alſo marked 75° but when in 38° 12 it marked 70°. Now conſidering that he had the warm influence of the gulph ſtream to the Northward, and that the ocean water to the ſouthward muſt naturally be warmer than that more North, out of the ſtream, there ſeems to be a perfect agreement between theory and fact with regard to the uſefulneſs of the thermometer in diſcovering the courſe of this current. The ſame thing occurred in the courſe of my paſſage in the London Packet with Doctor Franklin, (ſee Vol. 2 page 329 of the Tranſactions of this ſociety) in June

June 1785. The mean there was 73 while to the northward and ſouthward the thermometer marked 77.

Returning towards the coaſt of America, Captain Billings diſcovered his paſſage acroſs the gulph ſtream by a ſudden fall in the mercury of 5° from noon to night, and about 5° farther Weſt, by a further fall in the ſpace of 8 hours run, he diſcovered the coaſt, where he got ſoundings, before he ſaw the land.

The uſefulneſs of the thermometer as a nautical inſtrument is not confined to the diſcovery of an approach towards objects of danger *known to exiſt;* but it, may if attended to, diſcover others *not at preſent ſuppoſed to exiſt,* againſt which a navigator cannot be on his guard. Several charts, particularly one made by Governor Pownall, in September 1787, point out rocks and breakers in the middle of the ocean; ſome are ſaid to be uncertain, others have been ſeen but once, and preſerve the names of their ſuppoſed diſcoverers. Theſe facts are generally doubted, and by ſome mariners have been ridiculed; but it ſhould be conſidered that in every inſtance where the diſcovery of theſe hidden dangers have been fatal, no one could eſcape to tell the melancholy tale, and ſurely the number of miſſing ſhips juſtifies a conjecture that ſuch misfortunes have happened, and ought to influence every navigator to make accurate obſervations on the temperature of the ſea during the *whole* of his voyage.

A gentleman of undoubted veracity related to me ſome time ſince, the following fact, which I mention on account of its aptitude to this ſubject.

On a voyage from the Weſt-Indies to England, the ſmall veſſel he was in, touched at Bermuda. On leaving that iſland, having fine weather and a ſmooth ſea, they ſailed along a ridge of rocks, ſeeing the bottom very plain-

ly

ly all the time, till the iſland was out of ſight; in this place they ſpoke a large ſhip, the Captain of which, had no idea of his ſituation; he had not noticed the bottom, and was ſailing in full confidence of being far from danger. On being deſired to look over the ſide of his ſhip, the whole crew was in the utmoſt conſternation, and hove the ſhip too, with all her ſails ſett. He was ſoon informed of his true longitude, and took a new departure. Had this Captain kept a thermometrical journal he would not, probably, have been ſo deceived, and had he at this time been in a gale of wind, his error might have been fatal. Every body in this city remembers the dreadful cataſtrophe of the ſhip Faithful Steward, which was loſt, on this coaſt, with near 500 people on board, about ſeven years ſince. The Captain was ſo ſure of having ſufficient ſea room, that he did not think of ſounding, the weather was not boiſterous and had he known his ſituation he might have ſtood off during the night. But fearleſs of a danger he did not know, he ſtood on with full ſails, and was in an inſtant loſt: I think there were not above twenty ſouls ſaved. A thermometer regularly uſed would have given warning in time, and probably have ſaved theſe lives.

The impreſſion ſuch events have made on my mind, has induced me to be thus particular, and I the more readily do juſtice, to the judicious example given to other Captains, by Captain Billings, becauſe I think the obſervations of a mariner, are more likely to be attended to by mariners, than any inſtruction given by a landſman. I think beſides, that the merit of Captain Billings, ought to be rewarded, by a publication of his laudable conduct

that

that he may enjoy the reputation to which he is juſtly entitled.

I am with great reſpect, Sir
Your moſt obedient and
Moſt humble Servant,
JONATHAN WILLIAMS,
{One of the Secretaries of the American Philoſophical Society.}

A Thermometrical Journal of the temperature of the atmoſphere and ſea on a paſſage from Philadelphia to Oporto in the Ship Apollo, by Captain William Billings.

1791 Dates.	Time.	Places in at Noon Latt. N.	Lon. W.	Temp. of Air.	Water.	Notes.
June 6.	Sun-riſe.	38 56	75 07		61	Off Cape Henlopen.—N. B. The thermometer is on Fahrenheit's ſcale and the longitude Weſt from London.—The days are reckoned to begin at Noon and to end at the ſucceeding noon according to the uſage of navigators.
	2 P. M.	38 38	74 28		66	
	Sun ſett.			65	66	
8	10 A. M.				70	
	Noon.	37 18	72 34	75	72	
10	Noon.	38 03	68 49	73	77	
11	Noon.	38 51	65 57	66	75	
12	Noon.	39 02	63 22	71	71	June 8th. at 10 A. M. being the firſt alteration in the heat of the water after leaving the coaſt it is ſuppoſed we entered the gulph ſtream. The courſe is not acroſs, but rather along this current, ſomewhat diagonally however.
14	Noon.	39 11	56 48		62	
15	Noon.	39 37	53 43	71	65	
	From this date to the 2d July the variations in the heat of the ſea water do not exceed two degrees, they need not therefore be noticed.					
July 2d	Noon.	40 16	15 54	68	65	June 10th at noon it is ſuppoſed we are in the middle of the gulph ſtream.
3	Noon.	40 05	13 23	68	64	June 14th noon this ſudden fall of 9° is ſuppoſed to be owing to the influence of the banks of Newfoundland which bear about N.
4	Noon.	40 28	11 13	68	63	
5	2 P. M.			68	63	July 4th the water appears to have changed colour.
	7 P. M.				60	Land in ſight, but frequently obſcured by fog.
	8 A. M.				57	Land diſtant about 6 leagues.
	Noon.				55	Land diſtant about 2 leagues being the high land of Braganea nova

A Thermometrical

A Thermometrical Journal of the temperature of the atmoſphere and ſea, on a paſſage from Oporto to Philadelphia, in the Ship Apollo, by Captain William Billings.

1791 Dates.	Time.	Places in at Noon. Lat. N.	Long. W.	Temp. of Air.	Wat.	NOTES.
Aug. 4,	10 A. M.				57	Port barr: bearing E S E diſt. 7 leagues.
	Noon.	41 07	9 04		60	
5	Noon.	40 39	13 06	69	61	
6	8 A. M.			69	65	
	Noon.	40 35	17 06	69	67	But about half of degree difference
7	10 P. M.	40 29	20 24	68	68	of latitude during 5 days, and little
8	No on.	40 24	22 01	69	68	or no change in the temperature of the
9	No on.	41 00	22 49	68	68	ſea.
10	No on.	40 13	22 39	68	68	
11	No on.	38 42	24 02	69	71	N. B. 1 and ½ degree ſouthing water 3° warmer.
	10 P. M.				70	At 4 P M made the iſland St. Michael
	Midnight				69	Iſland diſt. 4 leagues, tack'd and ſtood
12	Noon.	37 57	24 55	72	70	off, at 5 A M. tack'd and ſtood to
14	Noon.	38 45	27 07	73	71	the ſouthward.
15	2 P. M.			72	70	Made the iſland Tercera. at 4 P. M.
	Sunſet.			72	69	
	Sunriſe.				68	Near Tercera, St. Georges and Pico in
16	2 P M.	38 24	27 51	73	70	ſight:
	Sunſet.				69	
	10 P. M.				68	Cloſe in with St. Georges.
	Midnight				69	
	Noon.	37 53	27 20	73	71	Land out of ſight.
17	10 P. M.			70	72	
	No on.	37 07	27 39		73	
18	Noon.	36 36	28 44		73	
19	Noon.	36 09	31 59		73	
20	Noon.	36 26	34 31	74	75	
21	10 P. M.			74	74	
	10 A. M.				70	
	Noon.				69	
22	Noon.	38 24	36 48		69	
23	Noon.	38 43	38 49	74	73	
24	10 P. M.	38 43	38 49	74	73	
	Noon.	38 44	41 32		71	
25	Noon.	39 04	44 17		75	
26	Noon.	38 56	46 44		75	
27	Noon.	38 12	50 10		70	
28	Noon.	37 02	51 28		75	
29	Noon.	38 08	52 31	74	74	
30	Noon.	37 47	53 20	74	75	
31	10 P. M.			72	70	
	Noon.	39 20	53 20		69	
Sept. 1,	Noon.	40 41	54 07	71	74	
2	Midnight			72	71	

A Thermometrical Journal of the temperature of the atmoſphere and ſea, on a paſſage from Oporto to Philadelphia, in the ſhip Apollo, by Capt. William Billings, continued.

1791 Dates.	Time.	Places in at Noon. Lat. N.	Long. W.	Temp. of Air.	Wat	Notes.
Sept. 2	Noon.	40 57	55 26	70	72	
3	Midnight				71	
	Noon.	40 56	57 51	70	73	
4	Noon.	39 10	59 18	74	74	
5	Noon.	39 17	61 11	74	76	
6	Midnight				77	This riſe indicates, the gulph ſtream.
	Noon.	40 06	63 20	74	78	
7	Noon.	40 36	66 03		75	
8	Noon.	40 01	67 23	73	77	
9	10 P. M.			71	73	This fall indicates the weſtern ſide of
	Midnight				72	the gulph ſtream.
	4 A. M.				71	
	Noon.	39 29	71 17		73	
10	Noon.	39 19	72 08	73	73	
11	Noon.	39 04	72 33	74	75	
12	Noon.	38 57	73 21	74	74	
13	Noon.	38 53	72 31	74	75	
14	Noon.	39 21	73 31	75	73	
15	6 P. M			74	69	
	8 A. M.				68	Sounded in 25 fathoms.

N°. XXIV.

Firſt Memoir of Obſervations on the Plants denominated *Cryptogamick.*

Nuſquam natura major quam in minimis.
PLIN.

Read Feb: 17, 1792.

ALTHOUGH the proceſs of nature in the formation and reproduction of all organiſed bodies is evidently uniform, yet there are philoſophers and naturaliſts who ſcruple to admit this general principle in all inſtances, and think it ſtill liable to ſome exceptions.

More